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5      1. Field of the Invention:

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## 15

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203c. The background image 203b is subtracted from the input image 203a, which is a composite image composed of a moving object 204 and the background image 203b, to obtain the background difference image 203c.

5 Specifically, a difference, between brightness values of the input image 203a and previously recorded brightness values of the background image 203b located at the same position as the input image 203a, is calculated. If the calculated difference is equal to or higher than  
10 a particular threshold, it is judged that a change in brightness value has occurred due to appearance of a moving object 204. Thus the moving object 204 is detected.

The term "brightness value" is a value representing  
15 a degree of fullness of light and shining per pixel in an image. The term "pixel" is a minute area on the display screen which area corresponds to a resolution of the image. Additionally, in the following description, the brightness value will also be called simply "brightness";  
20 the object which moves, "moving object"; the motion image, "image".

The background subtraction method has a problem in that mis-detection would tend to occur due to an environmental change, such as a change in weather, turning  
25 on and off the light or changeover of illumination. FIGS. 25(a) through 25(c) are graphs illustrating the manner in which a mis-detection occurs due to an environmental

change according to the background subtraction method. In the individual graph, the horizontal axis represents positions on the screen, and the vertical axis represents brightness values in these positions. In FIG. 25(a), two  
5 brightness distribution curves 205a, 205b are shown. The brightness distribution curve 205a is a string of brightness values of the original image (screen), while the brightness distribution curve 205b is a modified form which the brightness distribution curve 205a has been  
10 modified because light has been turned on.

As the brightness distribution curve 205a of FIG. 25(b) is subtracted from the brightness distribution curve 205b of FIG. 25(a), it produces a brightness distribution curve 205c corresponding to the difference  
15 in brightness value between the input image and the background image so that an environmental change would be mis-detected as a moving object.

Consequently, in order to avoid mis-detection due to an environmental change, a brightness distribution  
20 shape comparison method is used. In this comparison method, appearance/absence of an object is detected by dividing the image into a plurality of blocks, each composed of a number of pixels, and measuring a difference in shape of brightness distribution in each block. In the  
25 following description, the individual block is called "unit block" or "sub-area". This comparison method will now be described more specifically with reference to FIGS.

26(a), 26(b), 27(a) and 27(b).

FIGS. 26(a) and 26(b) illustrate a change of brightness occurs due to an environmental change. The input image 203a of FIG. 26(a) is a monitoring region composed of two areas A, B. The area A represents an area shaded from sunlight, and the area B represents an area bright with sunlight.

The change of brightness due to environmental change is not uniform in the monitoring region (corresponding to the input image 203a). For example, in each of the areas A, B, the change of brightness is not uniform. In a limited local area, this change of brightness can be regarded as being uniform. For example, the brightness change in a limited local area indicated by a white circle in the area B in FIG. 26(a) is as shown in FIG. 26(b). Two brightness distribution curves 205d, 205e of FIG. 26(b) represent respective brightness changes in the circled local area of the area B. The brightness distribution curve 205d represents a brightness distribution when the circled local area is bright with sunlight, and the brightness distribution curve 205e represents a brightness distribution when the circled local area is shaded from sunlight.

On the other hand, FIGS. 27(a) and 27(b) illustrate a brightness change around a moving object. The input image 203a of FIG. 27(a) has a moving object 204. The brightness distribution in a ridge 210 of the moving

object 204 is different in shape from the brightness distribution of the background image as shown in FIG. 27(b).

Therefore, by dividing the monitoring region into small unit blocks and obtaining a difference in shape of distribution of brightness values in the unit blocks between the input image and the background image, it is possible to detect appearance/absence of an object in terms of the individual unit blocks, irrespective of environmental changes.

This method is exemplified by "MOVING OBJECT DETECTION BY TIME-CORRECTION-BASED BACKGROUND JUDGEMENT METHOD" by Nagaya, et al., The Institute of Electronics, Information and Communication Engineers Theses Review (D-II), Vol.J79-D-II, No.4, pp. 568-576, 1996 (hereinafter called Publication 1), and "A ROBUST BACKGROUND SUBTRACTION METHOD FOR NON-STATIONARY SCENES" by Habe, et al., Meeting on Image Recognition and Understanding, MIRU '98 (hereinafter called Publication 2).

In a technology disclosed in Publication 1, brightness values in blocks are regarded as vector factors, and a normalized inter-vector distance of the input image is compared with that of the background image.

And in a technology disclosed in Publication 2, a variance in inter-block local distance of the input image is compared with that of the background image. In the

following description, the term "enter" means that an object have entered into a monitoring region, and the term "leave" means that an object leaves from a monitoring region.

5 Japanese Patent Laid-Open Publication No. HEI  
9-81753 (hereinafter called Publication 3) discloses a  
moving object extracting apparatus which can correctly  
identify a moving object even when a split of a moving  
area occurs in the same moving object because there is  
10 no adequate difference in brightness and tint between the  
input image and the background image. In Publication 3,  
when an object has concealed by another object, the  
concealing is detected, and then immediately after  
settlement of the concealing, the settlement is  
15 recognized to specify a settlement time, whereupon a  
shaped part of the intended object is trimmed from the  
detected moving area to extract a correct partial image  
of the intended object.

Japanese Patent Laid-Open Publication No. HEI  
20 5-174261 (hereinafter called Publication 4) discloses  
another moving object detecting apparatus which prevents  
mis-detection due to occurrence of shading by a moving  
object detector and due to change in illumination, based  
on a difference image.

25 Japanese Patent Laid-Open Publication No. HEI  
8-249471 (hereinafter called Publication 5) discloses  
still another motion image processing apparatus which

detects, evaluates and judges a characteristic amount of a moving object to realize a follow-up survey including a stop-status of the moving object despite using an inter-frame difference process. And if parameters  
5 determined by given environmental conditions are inadequate, they are soon substituted by optimal parameters to realize precise detection.

Japanese Patent Laid-Open Publication No. HEI 8-167022 (hereinafter called Publication 6) discloses an  
10 image monitoring apparatus which enable sure follow-up survey and detection of a moving object at an improved processing rate.

Japanese Patent Laid-Open Publication No. HEI 8-106534 (hereinafter called Publication 7) discloses  
15 another object moving detecting apparatus which detects a moving object in a monitoring area with accuracy and recognizes the detected moving object.

However, in the object detecting methods described in Publications 1 and 2, detection of an object is made  
20 chiefly by detecting a ridge of the object. Therefore, when an object flat in shape of brightness distribution enters an area whose shape of brightness distribution of background is flat, it is impossible to detect a movement of the object from inside of the area where the moving  
25 object appears. This will be described more specifically using FIGS. 28(a), 28(b), 29(a), 29(b), 30(a) and 30(b).

FIG. 28(a) schematically shows an input image in

which no object appears; the shape of a brightness distribution curve 211 is flat. And FIG. 28(b) schematically shows an input image in which an object appears; the object is a vehicle, for example, and the input image has areas 200a, 200b, 200d. In the areas 200a, 200d, since change in brightness distribution shape is large as compared to the brightness distribution curve 211 of FIG. 28(a), a movement of the object can be extracted.

In the meantime, in the area 200b which occupies an inner portion of the object-appearing area partly since the shape of the area 200b is analogous to the flat shape of the brightness distribution curve 211 of FIG. 28(a), a movement of the object cannot be detected. Since the real size of the object is not always proportional to the number of moving blocks to be detected, the following problems would occur.

FIG. 29(a) schematically shows an input image in which a single large-sized object, such as a vehicle, has entered. In FIG. 29(a), a brightness distribution curve of the object is flat in its central portion.

FIG. 29(b) is a top plan view showing a monitoring area in which a single large-sized object has entered. The monitoring area 23 is an area extracted from an input motion image. Small rectangles (quadrilateral) designated by 21 are areas, called moving blocks, whose brightness distribution changes have been detected by



comparison in terms of unit blocks.

FIG. 30(a) schematically shows an input image in which two small-sized objects, such as two persons, have entered. And FIG. 30(b) is a top plan view showing a monitoring area 23 in which two small-sized objects have entered. In FIG. 30(b), object ridges are many for the size of the moving objects, which is smaller than the example of FIG. 29(b). Since the nearly same number of moving blocks 21 as in the example of FIG. 29(b) would occur, discrimination cannot be made between these two examples.

FIG. 31 is an arrangement diagram of unit blocks and a ridge of an object. In FIG. 31, the ridge 201 of the object extends along an end of rectangular area of the individual unit block 20. Therefore, the change of brightness distribution in the unit block 20 would be so small to detect the object.

FIG. 32 schematically shows an input image when a camera (not shown) has encountered swing or vibration; for example, the camera is fixedly mounted in the open air. Even though the image 202a of FIG. 32 was taken at a normal position, the image of the object would be deviated as the camera angle varied, resulting in an image 202b and hence mis-detection.

Publications 3 through 7 are totally silent about either a technology of detecting two kinds of objects as discriminated or a technology of preventing mis-detection

due to swing or vibration of the camera.

#### SUMMARY OF THE INVENTION

5           With the foregoing problems in view, it is an object  
of the present invention to provide a moving object  
detecting method, in a technology of automatically  
extracting a movement of an object by detecting a moving  
area from an input image taken by a monitor camera, in  
10   which method a movement of an object can be detected  
irrespective of the shape of the object even in a varying  
environment where, for example, illumination varies, in  
which method a movement of an object can be detected  
irrespective of the positional relation between a ridge  
15   of the object and a border of unit blocks, and in which  
method only a moving object can be stably detected even  
when an environmental change, such as swing or vibration  
of a camera, happened to occur.

          Another object of the invention is to provide an  
20   apparatus for carrying out the above-mentioned moving  
object detecting method.

          In order to attain the first object, according to  
a first species of the present invention, there is  
provided a method of detecting a moving object,  
25   comprising: a first dividing step of dividing an input  
image into a plurality of first unit blocks; a second  
dividing step of dividing a given background image into

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a plurality of second unit blocks; a moving block  
extracting step of comparing the first unit blocks with  
the second unit blocks for every unit block and extracting  
a number of the first unit blocks, which are different  
5 in brightness distribution pattern from the corresponding  
second unit blocks, as moving blocks; a moving area  
setting step of setting a moving area that surrounds the  
moving blocks extracted in the moving block extracting  
step; and a brightness comparing step of comparing a  
10 distribution of brightness values of the input image with  
a distribution of brightness values of the background  
image in the moving area, which is set by the moving area  
setting step, to discriminate whether or not a moving  
object appears in the input image.

15 By the method of the first species, it is possible  
to facilitate making a discrimination between a single  
large-sized object and plural small-sized objects in a  
varying environment where, for example, light is turned  
on and off or illumination is varied, realizing a precise  
20 judgment on the area and position of an object.

As a preferable feature, the brightness comparing  
step may include: an appearance frequency measuring step  
of measuring a frequency of occurrence of pixels having  
a predetermined value; and a trimming step of trimming  
25 the pixels, whose appearance frequencies are lower than  
the predetermined value, from the pixels of the input  
image in the whole range of various brightness values.

As another preferable feature, in each of the first dividing step and the second dividing step, the individual first unit block may overlap neighboring unit blocks disposed adjacent to the last-named first unit block. As still another preferable feature, in the moving area setting step, the moving area surrounding the moving blocks may be rectangular in shape.

With these preferable features, it is possible to judge appearance/absence of an object based on the size of the object, realizing a precise detecting of a moving object.

According to a second species of the invention, there is provided a method of detecting a moving object, comprising: a monitoring region clipping step of clipping a monitoring region, which is to be monitored, from an input image; a region dividing step of dividing the monitoring region, which is clipped in the monitoring region clipping step, into a plurality of zones; a variance calculating step of calculating a variance of brightness values for each and every one of the plural zones obtained in the region dividing step; and an appearance detecting step of discriminating whether or not a moving object appears in the input image based on the variance calculated in the variance calculating step.

By the method of the second species, since variances are calculated, only a moving object can be stably detected even in a varying environment where a camera is

mounted outdoors and encounters change of illumination and swing or vibration.

As a preferable feature, the appearance detecting step may include: a history information creating step of  
5 creating history information about the variance calculated for every one of the plural zones obtained in the region dividing step; and a variance comparing step of comparing the past variance before a current time based on the history information created in the history  
10 information creating step with the current variance in the current time based on the input image to discriminate whether an moving object appears in the input image. As another preferable feature, in the appearance detecting step, if the number of the zones whose variance is equal  
15 to or higher than a first threshold is equal to or larger than a predetermined value, the appearance of the moving object is notified, and otherwise if the number of the zones whose variance is equal to or lower than a second threshold is equal to or larger than a predetermined value,  
20 the absence of the moving object is notified. As still another preferable feature, in the appearance detecting step, if the number of the zones whose increase value of variance is equal to or higher than a third threshold is equal to or larger than a predetermined value,  
25 the appearance of the moving object is notified, and if the number of the zones whose decrease value of variance is equal to or higher than a fourth threshold is equal

to or larger than a predetermined value, the absence of the moving object is notified.

As a further preferable feature, in the appearance detecting step, a reference value, based on which the increase value of variance and the decrease value of variance are to be calculated, is created from average values of the past variances before the current time. As a still further preferable feature, in the appearance detecting step, if the variance from which entering of the moving object is to be detected is equal to or higher than a first threshold, the appearance of the moving object is notified, and if the decrease value of variance from which leaving of the moving object is to be detected is equal to or larger than a fourth threshold, the absence of the moving object is notified. As another preferable feature, in the appearance detecting step, if an increase value of variance from which entering of the moving object is to be detected is equal to or higher than a third threshold, the appearance of the moving object is notified, and if the variance from which leaving of the moving object is to be detected is equal to or lower than a second threshold, the absence of the moving object is notified.

As an additional preferable feature, in the appearance detecting step, the monitoring region is set by expanding an assumed area of the moving object.

With these preferable features, since no background difference is utilized so that a possible swing of the

camera is not influential on variances, it is possible to detect an object precisely even when the came is swung or vibrated.

According to a third species, there is provided a  
5 method of detecting a moving object in an input image, comprising: a monitoring region clipping step of clipping a monitoring region, which is to be monitored, from the input image; a first region dividing step of dividing the monitoring region, which is clipped in the monitoring  
10 region clipping step, into a plurality of zones in a direction perpendicular to a direction in which the moving object enters; a variance calculating step of calculating a variance of brightness values for each and every one of the plural zones obtained in the first region dividing  
15 step; a zone discriminating step of discriminating whether an individual one of the plural zones is an object-appearing zone in which the moving object appears or an object-free zone in which the moving object is absent, by comparing the variance obtained in the variance  
20 calculating step with a predetermined value; and a moving-direction recognizing step of recognizing a direction in which the moving object moves, based on a direction of occurrence of the object-appearing zone found as the result of discrimination in the zone  
25 discriminating step.

As a preferable feature, the zone discriminating step uses a first discriminating way such that if the





provided an apparatus for detecting a moving object in  
an input image, comprising: an input image retaining  
section for retaining the input image; a background image  
retaining section, connected to the input image retaining  
5 section, for retaining a given background image; a  
background difference calculating section, connected to  
the input image retaining section and the background image  
retaining section, for calculating a difference between  
the input image and the background image; a moving  
10 direction recognizing section, connected to the input  
image retaining section, for dividing data of the input  
image into a plurality of pieces of data one piece for  
each of a plurality of zones and evaluating the data; and  
a united judging section, connected to the background  
15 difference calculating section and the moving direction  
recognizing section, for judging the appearance of the  
moving object and the direction of moving of the moving  
object.

With the apparatus of the fourth species, it is  
20 possible to detect the position and area of an object in  
an input motion image precisely without bearing the  
influence due to a swing or vibration of a camera.

As a preferable feature, the background difference  
calculating section includes: a block-background  
25 difference calculating unit, connected to the input image  
retaining section and the background image retaining  
section, for comparing first unit blocks related to the

input image with second unit blocks related to the background image to extract a moving block in which a change occurs in brightness distribution pattern; and an in-moving-area background difference calculating unit, connected to the block-background difference calculating unit, for setting a moving area surrounding the extracted moving block and comparing the distribution pattern of brightness values of the input image and the distribution pattern of brightness values of the background image to discriminate whether the moving object appears in the input image.

As an additional preferable feature, the moving direction recognizing section includes: a zone information retaining unit for retaining and outputting zone division information related to division of the input image into the plural zones; a variance calculating unit, connected to the zone information retaining unit and the input image retaining section, for dividing data of the input image, which is retained in the input image retaining section, into the plural pieces of data one piece for each the plural zones in accordance with the zone division information output from the zone information retaining unit, and for calculating variance of brightness values for every one of the plural zones; a variance history managing unit for retaining and outputting history information related to the past variance before the current time and calculated for each

and every one of the plural zones; and a variance  
evaluating unit, connected to the variance calculating  
unit and the variance history managing unit, for  
evaluating the variance calculated by the variance  
calculating unit and the history information output from  
the variance history managing unit.

With the apparatus of the fourth species, it is  
possible to realize high-resolution detection and also  
precise detection even when the camera is swung or  
vibrated.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a moving object  
detecting apparatus according to a first embodiment of  
the present invention;

FIG. 2 is a concept diagram illustrating how to  
arrange blocks by shifting;

FIG. 3 is an arrangement diagram of overlapping  
blocks and a ridge of an object;

FIG. 4(a) is a diagram showing an input image into  
which a single large-sized object has entered;

FIG. 4(b) is a diagram showing a monitoring region  
into which the single large-sized object has entered;

FIG. 5(a) is a diagram showing an input image into  
which a single small-sized object has entered;

FIG. 5(b) is a diagram showing a monitoring region

into which the single small-sized object has entered;

FIG. 6(a) is a graph showing a brightness distribution of a background image;

FIG. 6(b) is a graph showing a brightness  
5 distribution of an input image into which a single large-sized object has entered;

FIG. 7(a) is a graph showing a brightness distribution of a background image;

FIG. 7(b) is a graph showing a brightness  
10 distribution of an input image into which two large-sized objects have entered;

FIG. 8(a) is a graph showing a brightness distribution of an input image into which two small-sized objects have entered;

15 FIG. 8(b) is a histogram of brightness values of an input image into which the two small-sized objects have entered;

FIG. 8(c) is a graph showing a brightness distribution of the processed input image;

20 FIG. 9 is a block diagram showing a moving object detecting apparatus according to a second embodiment of the present invention;

FIG. 10 is a diagram showing a monitoring region into which a moving object has entered;

25 FIGS. 11(a) through 11(f) are diagram/graphs illustrating changes in variance values by area ratio;

FIG. 12(a) is a diagram showing an input image in

which no object appears;

FIG. 12(b) is a diagram showing an input image into which an object has entered;

FIG. 12(c) is a graph showing a frequency of occurrence of brightness values of pixels when no object appears in an input image;

FIG. 12(d) is a graph showing a frequency of occurrence of brightness values of pixels when an object has entered into the input image;

FIGS. 13(a) and 13(b) are graphs respectively showing brightness distributions of two kinds of objects;

FIGS. 14(a) and 14(b) are graphs each illustrating the method in which a variance is calculated for every zone;

FIG. 15 is a graph illustrating the method in which a threshold is determined when an object goes out of a zone;

FIG. 16 is a graph illustrating the manner in which an error detection is prevented according to the second embodiment;

FIG. 17 is a diagram showing a succession of zones obtained by dividing a monitoring region;

FIG. 18 is a diagram illustrating the manner in which an object is detected in a succession of zones;

FIG. 19 is a flow diagram showing the procedure in which a direction of movement of an object is detected according to the second embodiment;

FIG. 20 is a flow diagram showing the procedure in which a direction of movement of an object is detected when the object goes out according to the second embodiment;

5        FIG. 21 is a block diagram showing a moving object detecting apparatus according a modification of the second embodiment;

10        FIG. 22 is a flow diagram showing the procedure in which an object is detected in the moving object detecting apparatus according to the modification of the second embodiment;

FIG. 23 is a diagram showing a monitoring region when a moving area is rectangular;

15        FIG. 24 a diagram illustrating a background subtraction method;

FIGS. 25(a) through 25(c) are graphs respectively illustrating the procedure in which an error due to an environmental change using the background subtraction method;

20        FIGS. 26(a) and 26(b) are a view and a graph respectively illustrating a change in brightness due to an environmental change;

25        FIG. 27(a) and 27(b) are a view and a graph respectively illustrating a change in brightness at the periphery of a moving object;

FIG. 28(a) is a diagram showing an input image in which no object appears;

FIG. 28(b) is a diagram showing an input image in which an object appears;

FIG. 29(a) is a diagram showing an input image into which a single large-sized object has entered;

5        FIG. 29(b) is a diagram, as viewed from top, showing a monitoring region into which the large-sized object has entered;

FIG. 30(a) is a diagram showing an input image into which two small-sized objects have entered;

10       FIG. 30(b) is a diagram, as viewed from top, showing a monitoring region into which the two small-sized objects have entered;

FIG. 31 is a diagram showing an arrangement diagram of unit blocks and a ridge of an object; and

15       FIG. 32 is a diagram showing an input image when a camera has encountered vibration.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

20       Preferred embodiments of the present invention will now be described with reference to the accompanying drawings.

##### (A) First Embodiment:

25       FIG. 1 is a block diagram showing a moving object detecting apparatus according to a first embodiment of the present invention. The moving object detecting apparatus 10 of FIG. 1 detects a moving area, in which

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a movement has occurred, from input digital motion image data and automatically extracts a movement of an object from an input image. For this purpose, the moving object detecting apparatus 10 comprises an input image  
5 extracting section 11, an input image retaining section 12, a background image retaining section 13, a background difference calculating section 14, and an integrated judging section 16.

In FIG. 1, a camera 50 is a monitoring camera,  
10 mounted in, for example, a parking lot, for taking a motion picture of a vehicle entering into or going out of the parking lot. The individual motion picture (input image) taken by the camera 50 is converted into digital data, and the digital data is input to the moving object  
15 detecting apparatus 10. A solid-line arrow indicates a flow of data, and a dotted-line arrow indicates both a flow of data and the direction of referring the data.

The input image extracting section 11 of FIG. 1 extracts a monitoring region (to be monitored) from a  
20 motion image taken by the camera 50 and outputs the extracted monitoring region to the input image retaining section 12 as an input image for retaining. The background image retaining section 13 is connected to the input image retaining section 12 to retaining a background  
25 image.

Further, the background difference calculating section 14 is connected to both the input image retaining



section 12 and the background image retaining section 13  
for calculating a difference between the input image and  
the background image. For this purpose, the background  
difference calculating section 14 includes a block  
5 background difference calculating unit 14a, and an  
in-moving-area background difference calculating unit  
14b.

The block background difference calculating  
section 14a is connected to the input image retaining  
10 section 12 and the background image retaining section 13  
for comparing an input-image-related unit block 20 and  
a background-image-related unit block 20 to extract a  
moving block 21 in which a change in shape of brightness  
distribution. The position information of each of an  
15 input-image-related moving block and a  
background-image-related moving block is represented by  
x- and y-coordinates of the individual moving block.

Necessary terms will now be described with reference  
to FIG. 4(b) showing a monitoring region into which a  
20 single large-sized object has entered; a half-toned  
portion represents the moving object. The monitoring  
region 23 of FIG. 4(b) is a portion clipped off a motion  
image. A number of moving blocks 21 each represent a unit  
block in which an evidence of appearance of the object  
25 has been extracted; 12 moving blocks 21 have been detected  
in FIG. 4(b). And a moving area 22 represents the area

surrounding these moving blocks 21.

The block background difference calculating unit 14a (FIG. 1) makes a comparison in shape of brightness distribution between the input image and the background image for plural pixels of their corresponding unit blocks 20 at the same point. This comparison method is exemplified by the following two:

The first one is a method of calculating a vector angle between two vectors, which are brightness values of plural pixels of two unit blocks 20, and then recognizing the occurrence of a movement when the calculated vector angle becomes equal to or larger than a predetermined value. The vector angle can be obtained by an inner product.

The second one is a method of normalizing two vectors, which are brightness values of plural pixels of two unit blocks 20, then measuring a distance between these two vectors, and recognizing the occurrence of a movement when the measured distance is equal to or larger than a predetermined value.

The comparison method should by no means be limited to these two examples and various other methods may be suggested.

Detection of an object by the block background difference calculating section 14a is carried out with respect to unit blocks 20 overlapping one another. FIG. 2 is a concept diagram illustrating how to arrange blocks

by shifting. As shown in FIG. 2, in a region 100, eight (for example) unit blocks 20 are arranged in a pattern devoid of overlapping, while in a region 100a, the unit blocks 20 are arranged in a different pattern from that in the region 100. Namely, in the region 100a, some unit blocks 200 are overlapping adjacent unit blocks 20.

FIG. 3 is an arrangement diagram of overlapping blocks and a ridge of an object; elements or parts similar to those shown in FIG. 2 are designated by the same reference numbers. In the region 100a of FIG. 3, a ridge 101a extends centrally through a rectangular area of the individual unit block 20. It is therefore possible to precisely detect a change in brightness distribution in the unit blocks 20 and thus to precisely detect a movement of the object. It is also possible to capture a movement of the object, irrespective of the positional relation between borders of the unit blocks and a ridge of the object.

The in-moving-area background difference calculating section 14b (FIG. 1) is connected to the block background difference calculating section 14a for setting a moving area 22 surrounding an extracted moving block 21 and comparing a difference between distribution shape of brightness values of an input image and that of brightness values of a background image in the set moving area 22 to detect an object in the input image.

This comparison method also is exemplified by the

two methods mentioned above in connection with the block background difference calculating section 14a; namely, judgment of appearance of an object may be made in terms of a vector angle of two vectors generated by pixels in the moving area 22 of both the input image and the background image or in terms of the distance between the vectors.

The integrated judging section 16 is connected to the background difference calculating section 14 for judging on appearance of an object and on direction of movement of the object.

The function of each of the input image retaining section 12 and the background image retaining section 13, among the foregoing sections of the moving object detecting apparatus, is realized by a memory such as RAM (random access memory). And the functions of the remaining sections are realized by software processing according to non-illustrated CPU (central processing unit) and non-illustrated memories.

FIG. 4(a) is a diagram showing an input image into which a single large-sized object has entered; a half-toned portion in FIG. 4(a) represents the large-sized object having entered, as viewed in elevation. Regions 100b, 100c respectively represents regions where a movement is to be detected.

The input image is divided into a plurality of unit blocks 20 (first unit blocks) (first dividing step), and

the background image is divided into a plurality of unit blocks 20 (second unit blocks) (second dividing step). Then the first unit blocks 20 and the second unit blocks 20 are compared to extract the unit blocks 20, which are different in shape of brightness distribution, as "moving blocks 21" (moving block extracting step).

FIG. 4(b) is a diagram showing a monitoring region 23 in which a single large-sized object has entered and in which a plurality of moving blocks 21 have been extracted. Then a moving area 22 surrounding the extracted moving blocks 21 is set (moving area extracting step), and distribution of brightness values of an input image and that of brightness values of a background image are compared to detect an object in the set moving area 22 to discriminate whether or not a moving object appears in the input image (brightness comparing step).

FIG. 5(a) schematically shows a moving area in which two small-sized objects have entered, and FIG. 5(b) schematically shows a monitoring region 23 in which two small-sized objects have entered and in which a plurality of moving blocks 21 are arranged.

Subsequently, the difference of brightness distribution in the moving area 22 will now be described between when a single large-sized object enters and when two small-sized objects enter.

FIGS. 6(a) and 6(b) are graphs respectively showing a brightness distribution of a background image and that

of an input image when a single large-sized object has entered in the moving area 22. The shape of brightness distribution of the input image of FIG. 6(b) is considerably different from that of brightness distribution of the background image of FIG. 6(a).

FIGS. 7(a) and 7(b) are graphs respectively showing a brightness distribution of a background image and that of brightness distribution of an input image when two small-sized objects have entered in the moving area 22. As shown in FIG. 7(b), the brightness distribution of the input image has two peaks one at each of two positions in which the two moving objects respectively appear, and is substantially identical in shape with that of the background image of FIG. 7(a) throughout the entire area except the peaks.

Thus, by making a comparison of brightness distribution in the moving area 22 between the background image and the input image, it is possible to discriminate whether what has entered is a single large-sized object or two small-sized objects.

The method of precisely detecting an object in the moving area 22 in terms of appearance frequency will now be described with reference to FIGS. 8(a) through 8(c).

FIG. 8(a) is a graph showing a brightness distribution of an input image when two small-sized objects have entered.

This brightness distribution has two peaks respectively

at two positions, and has substantially at C in brightness value at the other positions. The brightness values at the two peaks are far different from those at the other positions.

5           FIG. 8(b) is a histogram of brightness values of the input image when two small-sized objects have entered. In FIG. 8(b), the horizontal axis indicates the brightness value, and the vertical axis indicates the appearance frequency (occurrence frequency) meaning how often a  
10   pixel having a predetermined brightness value has appeared, the appearance frequency having a peak at a brightness value C. Namely, in detecting an object, the frequency of occurrence of pixel having a predetermined value in the moving area 22 is calculated (appearance  
15   frequency calculating step).

Then the pixels at opposite ends whose appearance frequency is lower than a predetermined value in brightness distribution of the input image are trimmed from the brightness histogram curve of FIG. 8(b). At that  
20   time, several percent part of the entire brightness histogram curve, e.g. the pixels in 5 % range at each of upper and lower brightness values, is cut off. Thus the pixels, whose appearance frequency is lower than the predetermined value, from the pixels of the input image  
25   in the whole range of various brightness values (trimming step). FIG. 8(c) is a graph showing a brightness distribution of the input image after the trimming; a flat

distribution shape similar to that of the background image is obtained as the peaks have been removed.

The trimmed distribution shape is similar to that of the background image (FIG. 7(a)); therefore, based on the difference in brightness distribution shape between the input image and the background image, it is possible to facilitate discriminating whether what has entered is a single large-sized object or two small-sized objects. Even if the brightness value at the peak is close to that of the other background portions, there is no great influence as the pixels to be removed are only several percent part of the whole.

Thus by comparing in shape of brightness distribution between the input image and the background image, it is possible to facilitate discriminating whether what has entered is a single large-sized object or two small-sized objects, or to precisely detect an object.

With the foregoing construction, a moving object is detected in the following manner:

First of all, a motion image of a vehicle or a person entering a parking lot, for example, is taken by the camera 50 (FIG. 1). Then a monitoring region 23 of the motion image is clipped off by the input image extracting section 11 in the moving object detecting apparatus 10 and is retained in the input image retaining section 12 as an input image.





The result of this comparison is then input to the integrated judging section 16 where appearance of an object and an direction of movement of the object are judged in an integrated manner.

5           Thus, according to the first embodiment, it is possible to discriminate whether an object appears or not and to precisely detect a moving object.

10           It is also possible to realize a high-resolution detection with respect to the area and position of a moving object.

15           Further it is possible to facilitate discriminating whether what has entered is a single large-sized object or a plurality of small-sized objects, irrespective of the change of environment as illumination is on and off or degree of illumination is varied.

(B) Second Embodiment:

20           In the second embodiment, two detecting functions, i.e. detecting an object and detecting a direction of movement of the object, are realized by dividing a monitoring region into a plurality of zones and calculating variance for each and every zone. In the first embodiment, an object is detected by obtaining a difference between the input image and the background image. In the second embodiment, unlike the first  
25           embodiment, an object is detected by calculating variance of brightness values from the input image, and as an added function, a direction of movement of the object is

detected. In the following description, the term "variance" will occasionally be used to mean "variance value".

FIG. 9 is a block diagram of a moving object  
5 detecting apparatus according to the second embodiment. The moving object detecting apparatus 10a of FIG. 9 detects a movement of an object by detecting, from input digital motion image data, an area where a movement has occurred. For this purpose, the moving object detecting  
10 apparatus 10a comprises an input image extracting section 11, an input image retaining section 12, a moving-direction recognizing section 15, and an integrated judging section 16. In FIG. 9, elements or parts similar to those described in connection with the  
15 first embodiment are designated by the same reference numbers, so a repetition of description is omitted here. Further, in FIG. 9, a solid-line arrow indicates a flow of data, and a dotted-line arrow indicates both a flow of data and the direction of referring the data.

20 The moving direction recognizing section 15 is connected to the input image retaining section 12 for dividing the input image data into a plurality of pieces of data one piece for each zone to detect an object in the input image and recognize a direction of movement of  
25 the object. For this purpose, the moving direction recognizing section 15 includes a zone information retaining unit 15b, a variance calculating unit 15a, a

variance history managing unit 15d, and a variance judging unit 15c.

The zone information retaining unit 15b retains and outputs division information (hereinafter also called the zone division information) relating to division of the input image into a plurality of zones; this zone division information is determined by the size of an object to be detected and the direction of entering of the object. And the variance calculating unit 15a is connected to the zone information retaining unit 15b and the input image retaining section 12 for dividing the input image data, which is retained in the input image retaining section 12, into a plurality of pieces of data one piece for each zone based on the zone division information output from the zone information retaining unit 15b and calculating variance of brightness values for each and every zone.

The variance history managing unit 15d retains and outputs history information about past variance values for the individual zones; a value for the latest "no object" status is retained for the individual zone. This history information is information created based on the past variances calculated one for each zone.

The variance judging unit 15c is connected to the variance calculating unit 15a and the variance history managing unit 15d for detecting an object and determining the direction of movement of the object based on both the variance values calculated by the variance calculating

unit 15a and the history information output from the  
variance history managing unit 15d. Further, in the  
variance judging unit 15c, a predetermined value (or  
threshold) is previously set or a value for the latest  
5 "no object" status is obtained from the variance history  
managing unit 15d. During detection of a movement of an  
object, the variance judging unit 15c refers to history  
information of the variance history managing unit 15d to  
detect a monotonic increase or decrease of the plural  
10 zones in which appearance of an object has been detected.

The integrated judging section 16 is connected to  
the moving direction recognizing section 15 for judging  
both the appearance of an object and the direction of  
movement of the object; this function is realized using  
15 software.

First of all, a monitoring region 23a is clipped  
from the input image (monitoring region clipping step),  
and the clipped monitoring region 23a is divided into a  
plurality of zones (dividing step), whereupon variance  
20 of brightness values is calculated for each zone (variance  
calculating step). Then, based on the obtained variance,  
it is detected whether or not an object appears in the  
input image (detecting step). The detection procedure  
for the individual steps will now be described.

25 Description starts off with clipping a monitoring  
region 23a. FIG. 10 schematically shows the monitoring  
region 23a. The monitoring region 23a of FIG. 10 is

clipped from the input image so as to include both a moving object 104 and a background. The area of the monitoring region 23a is set to approximately double the area of the moving object 104 for the following reason.

FIGS. 11(a) through 11(f) illustrate changes of variances due to the area ratio. FIG. 11(b) schematically shows a monitoring region 23a whose area is double the area of the moving object 104; FIG. 11(a), a monitoring region 23a whose area is smaller than double the area of the moving object 104; FIG. 11(c), a monitoring region 23a whose area is larger than double the area of the moving object 104. FIG. 11(e) is a graph showing a brightness distribution of the monitoring region 23a whose area is double the area of the moving object 104; FIG. 11(d), a graph showing a brightness distribution of the monitoring region 23a whose area is smaller than double the area of the moving object 104; FIG. 11(f), a graph showing a brightness distribution of the monitoring region 23a whose area is larger than double the area of the moving object 104.

When the area of the monitoring region 23a is nearly double the area of the moving object 104, a maximal variance is obtained. In other words, as shown in FIG. 11(e), when the moving object 104 and a portion of the background image enter the monitoring area 23a individually by about 50% (area ratio is approximately 0.5), a variance is maximal.

Since detection of an object is carried out by the area ratio at which the maximum variance can be obtained, it is possible to improve the reliability. The value "2" representing the area ratio is adjusted and set to an optimum value in accordance with given guidelines for designing.

Then, the obtained monitoring region 23a is divided into a plurality of zones to generate history information about past variances calculated one for each of the plural zones (history information creating step).

Subsequently, detection of an object is carried out by comparing the past variances based on the history information with the current variances based on the input image (comparing step). The reason, why detection of an object is not carried out in terms of brightness in the monitoring region 23 (FIG. 4) like the first embodiment, will now be described with reference to FIGS. 12(a) through 12(d).

FIG. 12(a) schematically shows an input image in which no object appears; and FIG. 12(b), an input image in which an object has entered. FIG. 12(c) is a graph showing a frequency of occurrence of a brightness in the pixels when an object has entered; and FIG. 12(d), a graph showing a frequency appearance of a brightness in pixels when an object has entered. The horizontal axis of FIGS. 12(c) and 12(d) represents the brightness value (brightness), while the vertical axis represents the

appearance frequency (occurrence frequency); this is, the individual graph illustrates how often a predetermined brightness value has appeared.

Since the brightness of the input image of FIG. 12(a) is uniform, the brightness histogram of FIG. 12(c) has only a single peak. And the input image of FIG. 12(b) has a brightness histogram of FIG. 12(d) with two peaks respectively corresponding to the background image and the object image. Namely, the brightness histogram of FIG. 12(c) is small in variance of brightness values, while the brightness histogram of FIG. 12(d) is large in variance of brightness values.

As a result, a large difference in variance of brightness values in the monitoring region 23 occurs between before and after an object has entered in the monitoring region 23. Therefore, by calculating these variances of brightness values, it is possible to detect a movement of the object.

According to this method, since it is unnecessary to obtain the difference between the input image and the background image, detection would hardly encounter an error due to vibration of the camera 50. Since variance of brightness values would scarcely vary due to the change in luminosity of the circumference, it is possible to improve the resistance to change of environment, realizing a less-occurrence-of-error detection.



However, since this change in variance bears influence of not only the size of a moving object but its brightness value, a small-sized object and a large-sized object would occasionally cause the same variance.

FIGS. 13(a) and 13(b) are graphs respectively showing brightness distributions of two kinds of objects. Specifically, the brightness distribution of FIG. 13(a) indicates "a small-area object whose brightness value is far remote from that of the background image", while the brightness distribution of FIG. 13(b) indicates "a large-area object whose brightness value is close to that of the background image". The brightness distributions of FIGS. 13(a) and 13(b) are different in shape from each other, but are close in variance to each other.

It is therefore impossible to discriminate these two kinds of objects one from the other by only variance. Consequently, the brightness distribution is divided into a plurality of zones in order to calculate variances.

FIGS. 14(a) and 14(b) respectively illustrate how to calculate variances for every zone. For example, the brightness distribution of each of FIGS. 14(a) and 14(b) is divided into six zones (indicated by 1 through 6).

Specifically, for the brightness distribution of FIG. 14(a), variance is calculated for every zone; as a result, no change is detected in any of the zones 1-3, 5, 6, while a change is detected in the zone 4. For the brightness distribution of FIG. 14(b), as the result of

calculation of variances, no change is detected in either of the zones 1, 6, while a change is detected in each of the zones 2-5. Namely, the zones where the variance varies are few in FIG. 14(a), while those where the variance varies are many in FIG. 14(b).

Thus, by diving the brightness distribution into zones, it is possible to make a discrimination between "a small-area object whose brightness value is far remote from that of the background" and "a large-area object whose brightness value is close to that of the background".

This detection is exemplified by two methods. According to the first method, appearance of an object is notified when the number of zones, whose variance is equal to or higher than a first threshold, is equal to or larger than a predetermined value, and absence of any object is notified when the number of zones, whose variance is equal to or lower than a second threshold, is equal to or larger than the predetermined value.

FIG. 15 is a graph showing how to determine a threshold when an object leaves from the zone; this variance curve varies in brightness value with time.

According to the second method, appearance of an object is notified when the number of zones, whose increase of variance is equal to or higher than a third threshold, is equal to or larger than a predetermined value, and absence of any object is notified when the

number of zones, whose decrease of variance is equal to or higher than a fourth threshold, is equal to or larger than a predetermined value. Assuming that an object has entered into the monitoring region 23a, the extent of variation of variance depends on the shape of brightness distribution caused by a moving object; therefore an observer cannot estimate a variance. For this reason, according to the first method, it is difficult to set the first threshold; consequently, evaluation is made in terms of a relative value from the current variance when detecting that an object has entered into the monitoring region 23a.

FIG. 16 is a graph illustrating how to prevent a mis-detection in the second method. In FIG. 16, when variation of variance from a reference value is detected, a mis-detection occasionally occurs due to a temporary change of variance. Assuming that leaving of an object from the monitoring region 23a is monitored, variance occasionally increases at a position, indicated by P1 in FIG. 16, as the object moves across the monitoring region 23a. At that time, since decreasing of variance is monitored all the time, it is judged that variance has apparently decreased in a short time.

By comparing an average value of the past variances with the current variance, a real decrease extent is detected at a position indicated by P2 in FIG. 16, thus avoiding a possible mis-detection at the position P1.



entering and leaving of an object.

How to detect the direction of movement of an object using variances will now be described. In the moving direction detection, like the above-mentioned object  
5 detection, first of all, a monitoring region 23a is clipped from the input image (monitoring region clipping step).

FIG. 17 is a diagram showing a plurality of zones as the result of dividing the monitoring area 23a.

10 Assuming that an object enters the monitoring area 23a from right to left in FIG. 17, the monitoring area 23a is divided perpendicularly to the direction of entering of the object to thereby create N (N is an integer) zones  $Z_1, Z_2, \dots, Z_N$  (first zone creating step). Then variance  
15 of brightness values is calculated for each of the created zones  $Z_1, Z_2, \dots, Z_N$  (variance calculating step). Then the obtained variance is compared with a predetermined value to discriminate whether the individual zone  $Z_1, Z_2, \dots, Z_N$  is an appearance-of-object zone, in which an object  
20 appears, or a devoid-of-object zone, in which no object appears (zone discriminating step). In the meantime, the direction of movement of an object is recognized based on the direction of occurrence of the appearance-of-object zone (moving direction recognizing  
25 step).

FIG. 18 illustrates how to detect an object in a succession of zones. Out of the zones  $Z_1, Z_2, \dots, Z_N$  of

FIG. 18; the object-detected zones Z1, Z2, Z3, in which an object has been detected, are half-toned, and the object-undetected zones ZN, in which no object has been detected, are left unhalf-toned.

5           The discrimination between the object-detected zone and the object-undetected zone, like the above-mentioned object detection, is exemplified by two methods. According to the first discriminating method, the individual zone Z1, Z2,..., ZN is judged as an  
10 appearance-of-object zone when variance is equal to or higher than a predetermined value, and is judged as a void-of-object zone when variance is lower than a predetermined value. In addition, the individual zone Z1, Z2,..., ZN is judged as an appearance-of-object zone when  
15 the extent of variation of variances is equal to or larger than a predetermined value, and is judged as a void-of-object zone when the extent of variation of variances is smaller than a predetermined value. Namely, discrimination is made as an absolute value of variance  
20 or a relative value of variance variation is compared with a predetermined value. This predetermined value is created from the average value of variance of the past brightness values.

Then, as shown in FIG. 18, if appearance of an object  
25 has been detected successively in the zones Z1, Z2, Z3, the zones Z1, Z2, Z3 are judged as zones in which an object has entered. Of these last-named zones, a

minimum-numbered zone Z1, whose zone number is minimal,  
and a maximum-numbered zone Z3, whose zone number is  
maximal, are extracted. The term "minimum-numbered  
zone" means a zone Z1 from which an object has entered  
5 into the monitoring region 23a, and the term  
"maximum-numbered zone" means a zone Z3 toward which the  
object has moved in the monitoring region 23a.

Further, using either the first discriminating  
method or the second discriminating method, the direction  
10 of movement of an object is recognized. For example, when  
detecting that an object leaves from the monitoring region  
23a, there occurs no great difference in change between  
the images before and after the object has entered.  
Therefore, by comparing the previously recorded variance  
15 of the image, which is before the object has entered, with  
the variance of the current image, it is possible to  
realize detection with high precision. These two  
discriminating methods may be selectively used one to  
detect the entering of an object into the monitoring  
20 region 23a and the other to detect the leaving of an object  
from the monitoring region 23a.

The signal (data) flow will now be described with  
reference to FIG. 9. First of all, a monitoring region  
23a is trimmed from a motion image taken by the camera  
25 50 by the input image extracting section 11. This  
monitoring region 23a is then retained in the input image  
retaining section 12. And variance is calculated for

every zone by the moving direction recognizing section 15. The zone division information about how to divide the monitoring region 23a into zones Z1, Z2,..., ZN are retained in the zone information retaining unit 15b, and the input image data retained in the input image retaining section is divided into a plurality of pieces of data one piece for each of zones Z1, Z2,..., Zn, based on the zone division information output from the zone information retaining unit 15b, by the variance calculating unit 15a to thereby calculate variance of brightness values for every zone.

The variance history managing unit 15d retains and outputs the history information of the respective past variance of plural zones, and the variance judging unit 15c detects an object and judges the direction of movement of the object, based on both the variances calculated by the variance calculating unit 15a and the history information output from the variance history managing unit 15d. And the integrated judging unit 16 judges appearance of the object and the direction of movement of the object in an integrated manner.

With this construction, detection of entering of an object and detection of leaving of an object can be carried out. FIG. 19 is a flow diagram illustrating how to detect the direction of movement of an object according to the second embodiment. First of all, a plurality of successive zones are obtained, and a longest succession



of zones, in which a largest number of zones succeed, is obtained (step A1). In this longest succession of zones, it is discriminated whether or not the minimum zone number is 1 or a smaller number close to 1 (step A2). If the  
5 minimum zone number is 1 or a smaller number close to 1, the procedure takes YES route to go to step A4 at which it is discriminated whether or not the maximum zone number increases monotonically, based on the history information from the variance history managing unit 15d. If the  
10 maximum zone number increases monotonically, the procedure takes YES route to go to step A6 at which it is judged that the movement of the object is a correct movement.

Otherwise, if the minimum zone number is not 1 or  
15 a smaller number close to 1 (step A2), the procedure takes NO route to go to step A3 at which it is judged that the movement of the object is an incorrect movement. Likewise, if the maximum zone number does not increase monotonically (step A4), the procedure takes NO route to go to step A5  
20 at which the movement of the object is an incorrect movement.

Thus if the minimum zone number is neither 1 nor a smaller number close to 1 and the maximum zone number increases monotonically, it is judged that the object  
25 enters; since, if otherwise, it is judged that an ignorable object other than an intended object to be detected enters, an error-free detection can be achieved.

FIG. 20 is a flow diagram illustrating how to detect the direction of movement of an object, when it leaves from the monitoring region 23a, according to the second embodiment. During detection of a leaving object, like detection of an entering object, first of all, the variance judging unit 15c obtains a plurality of successive zones, and a longest succession of zones, in which a largest number of zones succeed, are obtained (step B1). In the longest number of successive zones, it is discriminated whether or not the minimum zone number is 1 or a smaller number close to 1 (step B2). If the minimum zone number is 1 or a smaller number close to 1, the procedure takes YES route to go to step B4 at which it is discriminated whether or not the maximum zone number decreases monotonically, based on the history information from the variance history managing unit 15d. If the maximum zone number decreases monotonically, the procedure takes YES route to go to step B6 at which it is judged that the movement of the object is a correct movement.

Otherwise, if the minimum zone number is not 1 or a smaller number close to 1 (step B2), the procedure takes NO route to go to step B3 at which it is judged that the movement of the object is an incorrect movement. Likewise, if the maximum zone number does not decrease monotonically (step B4), the procedure takes NO route to go to step B5 at which the movement of the object is an incorrect

movement.

Thus if the minimum zone number is not 1 or a smaller number close to 1 and the maximum zone number decreases monotonically, it is judged that the object leaves; since, if otherwise, it is judged that an ignorable object other than an intended object to be detected leaves, an error-free detection can be achieved.

Thus, according to the second embodiment, by capturing variations of variance due to the movement of an object, it is possible to detect both an object and the direction of movement of the object with precision. It is therefore possible to detect only an intended moving object stably even in a non-stable environment, such as outdoor.

(B1) Modification of the Second Embodiment:

In this modification, the detection method of the second embodiment is combined with that of the first embodiment to detect a moving object with improved precision.

FIG. 21 is a block diagram showing a hybrid moving object detecting apparatus according to this modification of the second embodiment. This hybrid moving object detecting apparatus 10b of FIG. 21 detects a moving area, in which an movement has occurred, from input digital motion image data and automatically extracts a movement of an object from an input image. For this purpose, the moving object detecting apparatus 10 comprises an input

image extracting section 11, an input image retaining  
section 12, a background image retaining section 13, a  
background difference calculating section 14, an moving  
direction recognizing section 15 and an integrated  
5 judging section 16. The integrated judging section 16 is  
connected to the background difference calculating  
section 14 and the moving direction recognizing section  
15 for making a judgment on appearance of an object and  
direction of movement of the object. In FIG. 21, elements  
10 or parts similar in function to those described in  
connection with the first and second embodiments are  
designated by the same reference numbers, so any  
repetitive description is omitted here. In FIG. 21, a  
solid-line arrow indicates a flow of data, and a  
15 dotted-line arrow indicates both a flow of data and the  
direction of referring the data.

The input image extracting section 11 extracts, as  
in input image, the individual motion picture taken by  
the camera 50. Then a block background difference  
20 calculating unit 14a in the background difference  
calculating section 14 measures a vector distance between  
the input image and the background image by subtracting  
an average value from the individual vector factor as  
assumed that the individual pixels in a unit block 20 are  
25 vector factors. If the measured vector distance is equal  
to or larger than a predetermined value, it is recognized  
that a change has occurred in shape of distribution of

brightness values, namely, occurrence of a movement.

Then the in-moving-area background difference calculating unit 14b, in which a moving area 22 surrounding the extracted moving blocks 21 is set, calculates a difference in shape of distribution of brightness values between the input image and the background image in the moving area 22 to thereby detect appearance of an object in the input image.

In short, the background difference is utilized in detection of an object.

In the meantime, the moving direction recognizing section 15 utilizes variance to detect a moving object and the direction of movement of the object. A zone information retaining unit 15b retains and outputs division information (hereinafter also called the zone division information) relating to division of the input image into a plurality of zones  $Z_1, Z_2, \dots, Z_N$ . And a variance calculating unit 15a divides the input image data, which is retained in the input image retaining section 12, into a plurality of pieces of data one piece for each zone  $Z_1, Z_2, \dots, Z_N$  based on the zone division information output from the zone information retaining unit 15b and calculates variance of brightness values for each and every zone  $Z_1, Z_2, \dots, Z_N$ .

Further, a variance history managing unit 15d retains and outputs history information about past variance values for the individual zones. And a variance

judging unit 15c detects an object and determines the direction of movement of the object based on both the variance values calculated by the variance calculating unit 15a and the history information output from the variance history managing unit 15d.

Then the integrated judging section 16 judges appearance of an object and the direction of movement of the object in an integrated manner. FIG. 22 is a flow diagram illustrating how to detect an object in the hybrid moving object detecting apparatus 10b according to this modification of the second embodiment. First of all, at step C1, a ratio of the moving blocks 21 occupying in the monitoring region 23 (or 23a) is obtained. If the ratio is large, the procedure takes RATIO-LARGE route to go to step C2 at which comparison in brightness distribution in the moving area 22 takes place. At step C1, if the ratio of the moving blocks 21 is small, the procedure takes RATIO-SMALL route to go to step C3 at which no object is detected as the change in brightness distribution between the input image and the background image is recognized as an environmental change due to weather change, illumination or any ignorable cause.

Further, at step C2, a difference in brightness between the moving area 22 and the background image is calculated. If the calculated difference is large, the procedure takes DIFFERENCE-LARGE route to go to step C4. If the difference is small, the procedure takes

DIFFERENCE-SMALL route to go to step C5 at which no object is detected as the change in brightness distribution is recognized as a change due to occurrences of plural small-sized moving objects, which are ignorable.

5           Then at step C4, a change in variance is calculated. If a change occurs in variance, the procedure takes YES route to go to step C6. Otherwise if no change occurs in variance, the procedure takes NO route to go to step C7 at which no object is detected as the change is recognized  
10 as a change due to swing or vibration of the camera 50.

          In addition, at step C6, the direction of movement of an object is discriminated. If the direction of movement is correct, the procedure takes CORRECT route to go to step C8 at which the movement of the object is  
15 detected. Otherwise if the direction of movement is incorrect, the procedure takes INCORRECT route to go to step C9 at which no object is detected as the change in variance is recognized as a change due to another movement of the object and hence ignorable object.

20           According to this modification of the second embodiment, since the method of the first embodiment, in which a moving object in the input image is detected by calculating a difference in brightness distribution between the input image and the background image, and the  
25 method of the second embodiment, in which a moving object is detected utilizing variance, are combined, it is possible to detect a moving object with improved

precision.

Further, since the moving object detecting method utilizing variance does not require a difference between the input image and the background image, it is possible to detect a moving object stably even when the camera encounters swing or vibration, which would be a cause for mis-detection.

Furthermore, since a difference between the input image and the background image is calculated, it is possible to detect the position and area of an object with high resolution and also to realize a precise detection which is free of any effect due to swing or vibration of the camera.

For additional advantageous features, it is possible to facilitate making a discrimination between a single large-sized object and a plurality of small-sized objects, irrespective of the environmental change such as due to turning on and off the light or changing over the illumination.

#### (C) Other Modifications:

The present invention should by no means be limited to the illustrated embodiments and modification, and various other modifications may be suggested without departing from the gist of the invention.

For example, the moving area 22, which is oval in shape in the first embodiment as shown in FIG. 4(b), may have a rectangular (quadrilateral) shape.



FIG. 23 shows a monitoring region 23b when a moving area 22 has a rectangular shape such as to surround the moving blocks 21. Given that the moving area 22 is set to be rectangular in shape, (x, y) coordinates can be utilized, it is possible to reduce an amount of arithmetic operation for retrieving in program processing.

Further, in the second embodiment, the monitoring region 23a is divided into a plurality of zones. Alternatively, instead of dividing, variances may be calculated for the original monitoring area 23a to execute detection of an object and detection of the direction of movement of the object.